Carbamate Pesticides

General Information

Carbamate pesticides are widely used against insects, fungi, and weeds. Their estimated annual use worldwide ranged from 20,000 to 35,000 tons (International Programme on Chemical Safety, 1986). The carbamates are used on agricultural crops and on residential lawns and gardens by homeowners and professionals. In the United States, the annual use of the carbamate insecticide, carbaryl, during the period 1995-1996 was between 1 and 3 million pounds. Carbamate insecticides do not persist long in the environment, so they tend not to bioaccumulate.

Exposure of the general population to these pesticides occurs primarily from ingestion of food products or from residential use. The FDA, U.S. EPA, and OSHA have developed criteria on the allowable levels of these chemicals in foods, the environment, and the workplace. Additional sources of exposure include aerial spraying of these chemicals and workplace exposure during the manufacture, formulation, or application of these chemicals. Both dermal and inhalational routes of entry can occur in workers. Carbamate insecticides inhibit acetylcholinesterase, leading to an increase of acetylcholine at certain nerve terminals, and causing symptoms such as weakness and sometimes paralysis. Generally, carbamate insecticides inhibit acetylcholinesterase activity for a shorter amount of time than do organophosphate pesticides.

This *Report* provides measurements for the urinary metabolites of six carbamate insecticides. Table 170 shows the various metabolites measured in this *Report* and their parent carbamate pesticides. For example, propoxur metabolizes to 2-isopropoxyphenol. The presence of these chemicals generally reflects recent exposure to carbamate insecticides. Some of the metabolites can be produced from the metabolism of more than one insecticide. Although the presence of 1-naphthol in the urine can occur from carbaryl exposure, it may also result from exposure to naphthalene (e.g., in older types of mothballs), fires, and smoking (see the section titled "Pest Repellents and Disinfectants"). In addition to reflecting exposure to the parent insecticide, the level of the metabolite in a person's urine may reflect exposure to the metabolite itself.

Interpreting Urine Carbamate Insecticide Metabolite Levels Reported in the Tables

Generally recognized guidelines for urine levels of these metabolites have not been established. Urine levels of the metabolites of carbamate insecticides were measured in a subsample of NHANES 1999-2000 participants aged 6-59 years. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. Measuring these chemicals at these levels is possible because of advances in analytical chemistry. Finding a measurable amount of one or more metabolites in the urine does not mean that the levels of the carbamate insecticide cause an adverse health effect. Whether carbamate pesticides at the levels reported here are cause for health concern is not known; more research is needed.

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of carbamates than those found in the general population. These data will help scientists plan and conduct research about exposure to carbamates and health effects.

Table 170. Carbamate insecticides and their metabolites

Carbamate insecticide (CAS number)	**Primary urinary metabolite** (CAS number)
Carbaryl (63-25-2)	1-Naphthol (90-15-3)
Propoxur (114-26-1)	2-Isopropoxyphenol (4812-20-8)
Carbofuran (1563-66-2)	Carbofuranphenol (1563-38-8)
Benfuracarb (82560-54-1)	Carbofuranphenol (1563-38-8)
Carbosulfan (55285-14-8)	Carbofuranphenol (1563-38-8)
Furathiocarb (65907-30-4)	Carbofuranphenol (1563-38-8)

1-Naphthol

CAS No. 90-15-3

Metabolite of carbaryl (CAS No. 63-25-2) and other chemicals

Carbaryl is metabolized to 1-naphthol. Both 1-naphthol and 2-naphthol may result from exposure to naphthalene in older types of mothballs, fires that produce PAHs, and tobacco smoke. Thus, these metabolites in the urine may reflect multiple sources of exposure.

The levels of 1-napthol reported here are lower than levels measured in a non-random subsample from NHANES III (1988-1994) participants (Hill et al., 1995). The median level in the NHANES III subsample was about two to three times higher than the median level for adults reported here. In addition, the urinary 1-naphthol levels for the group aged 6-11 years in this *Report* are similar to levels reported for Minnesota children aged 3-13 years (adjusted for sociodemographic factors) in 1997 (Adgate et al., 2001). In a population of Maryland adults, the median urinary 1-naphthol level was 4.2 µg/L (MacIntosh et al., 1999) compared with the median level of 1.4 µg/L reported here. There were no differences in 1-naphthol levels among the various age, gender, or race/ethnic groups.

Table 171. 1-Naphthol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	1.70 (1.38-2.09)	< LOD	< LOD	1.22 (1.00-1.60)	2.72 (1.90-3.76)	6.20 (4.10-9.60)	12.0 (7.20-19.0)	1998
Age group								
6-11 years	*	< LOD	< LOD	1.11 (<LOD-1.60)	2.30 (1.50-3.10)	3.61 (3.00-5.10)	5.60 (4.20-11.0)	483
12-19 years	1.54 (1.22-1.94)	< LOD	< LOD	1.20 (<LOD-1.50)	2.16 (1.60-3.80)	6.00 (3.20-11.0)	8.70 (5.20-19.0)	682
20-59 years	1.79 (1.43-2.23)	< LOD	< LOD	1.40 (1.10-1.70)	2.90 (2.10-4.10)	6.60 (4.20-12.0)	14.0 (7.20-22.0)	833
Gender								
Males	1.73 (1.42-2.11)	< LOD	< LOD	1.40 (1.10-1.80)	2.90 (2.00-3.90)	6.60 (4.40-9.00)	11.0 (7.20-16.0)	974
Females	1.67 (1.33-2.10)	< LOD	< LOD	1.30 (<LOD-1.63)	2.60 (1.80-3.80)	6.20 (3.71-13.0)	14.0 (6.30-22.0)	1024
Race/ethnicity								
Mexican Americans	1.48 (1.19-1.85)	< LOD	< LOD	1.10 (<LOD-1.70)	2.20 (1.60-3.10)	4.50 (3.00-6.70)	7.70 (4.60-14.0)	697
Non-Hispanic blacks	1.80 (1.42-2.28)	< LOD	< LOD	1.38 (1.10-1.80)	3.10 (1.89-4.80)	7.10 (4.40-13.0)	13.0 (7.20-41.0)	524
Non-Hispanic whites	1.70 (1.32-2.18)	< LOD	< LOD	1.30 (<LOD-1.60)	2.70 (1.80-3.90)	5.90 (3.70-11.0)	11.0 (5.90-21.0)	602

< LOD means less than the limit of detection, which is 1.0 µg/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 172. 1-Naphthol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	1.52 (1.24-1.85)	< LOD	< LOD	1.25 (1.00-1.61)	3.00 (2.26-4.18)	6.80 (5.09-9.70)	11.6 (8.33-16.8)	1998
Age group								
6-11 years	*	< LOD	< LOD	1.34 (1.13-1.73)	2.57 (1.93-3.18)	4.53 (3.78-6.83)	8.21 (4.67-13.9)	483
12-19 years	1.04 (.839-1.29)	< LOD	< LOD	.845 (.652-1.04)	2.00 (1.24-2.91)	4.42 (2.67-6.20)	6.20 (3.78-10.0)	682
20-59 years	1.64 (1.32-2.05)	< LOD	< LOD	1.33 (1.08-1.78)	3.43 (2.36-4.87)	8.46 (5.77-11.5)	13.5 (8.65-19.7)	833
Gender								
Males	1.33 (1.09-1.61)	< LOD	< LOD	1.13 (.866-1.37)	2.41 (1.79-3.43)	6.23 (4.09-8.76)	10.0 (7.14-12.8)	974
Females	1.73 (1.39-2.16)	< LOD	< LOD	1.51 (1.15-1.91)	3.80 (2.54-4.79)	7.92 (5.50-12.8)	13.5 (8.33-19.7)	1024
Race/ethnicity								
Mexican Americans	1.34 (1.05-1.70)	< LOD	< LOD	1.18 (.899-1.61)	2.42 (1.68-3.44)	4.80 (3.54-6.32)	7.08 (4.95-8.86)	697
Non-Hispanic blacks	1.22 (.956-1.57)	< LOD	< LOD	.983 (.765-1.26)	2.46 (1.55-4.15)	7.19 (4.29-10.4)	10.7 (6.80-14.8)	524
Non-Hispanic whites	1.60 (1.24-2.06)	< LOD	< LOD	1.32 (1.00-1.81)	3.16 (2.18-4.73)	7.69 (5.00-11.5)	13.5 (7.92-18.9)	602

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

2-Isopropoxyphenol

CAS No. 4812-20-8

Metabolite of propoxur (CAS No. 114-26-1)

2-Isopropoxyphenol was detected in only 1.2% of the NHANES 1999-2000 subsample. In a non-random subsample from NHANES III (1988-1994), the 95th percentile level of 2-isopropoxyphenol was 1.7 µg/L (Hill et al., 1995).

Table 173. 2 - Isopropoxyphenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1917
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	456
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	655
20-59 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	806
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	936
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	981
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	664
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	500
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	584

< LOD means less than the limit of detection, which is 1.1 µg/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 174. 2-Isopropoxyphenol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	1917
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	456
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	655
20-59 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	806
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	936
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	981
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	664
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	500
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	< LOD	584

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Carbofuranphenol

CAS No. 1563-38-8

Metabolite of benfuracarb, carbofuran, and other chemicals

In a non-random subsample from NHANES III (1988-1994), the 99th percentile level of carbofuranphenol was 2.1 µg/L (Hill et al., 1995).

Table 175. Carbofuranphenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	*	< LOD	< LOD	< LOD	< LOD	< LOD	.740 (<LOD-1.30)	1994
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	.430 (<LOD-2.16)	482
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	.570 (<LOD-1.20)	681
20-59 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	.840 (<LOD-1.50)	831
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	.740 (<LOD-1.30)	973
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	.840 (<LOD-1.70)	1021
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	.570 (<LOD-1.90)	1.90 (<LOD-3.70)	696
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	.430 (<LOD-1.50)	521
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	.740 (<LOD-1.50)	602

< LOD means less than the limit of detection, which is 0.4 µg/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 176. Carbofuranphenol (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 to 59 years, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6-59	*	< LOD	< LOD	< LOD	< LOD	< LOD	.777 (.638-1.00)	1994
Age group								
6-11 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	.988 (.435-2.63)	482
12-19 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	.472 (.326-.778)	681
20-59 years	*	< LOD	< LOD	< LOD	< LOD	< LOD	.824 (.638-1.06)	831
Gender								
Males	*	< LOD	< LOD	< LOD	< LOD	< LOD	.655 (.500-1.08)	973
Females	*	< LOD	< LOD	< LOD	< LOD	< LOD	.875 (.667-1.06)	1021
Race/ethnicity								
Mexican Americans	*	< LOD	< LOD	< LOD	< LOD	.778 (.438-1.65)	1.83 (.778-3.33)	696
Non-Hispanic blacks	*	< LOD	< LOD	< LOD	< LOD	< LOD	.645 (.318-1.08)	521
Non-Hispanic whites	*	< LOD	< LOD	< LOD	< LOD	< LOD	.717 (.609-.881)	602

< LOD means less than the limit of detection (see previous table).

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.